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Leaf Beetle

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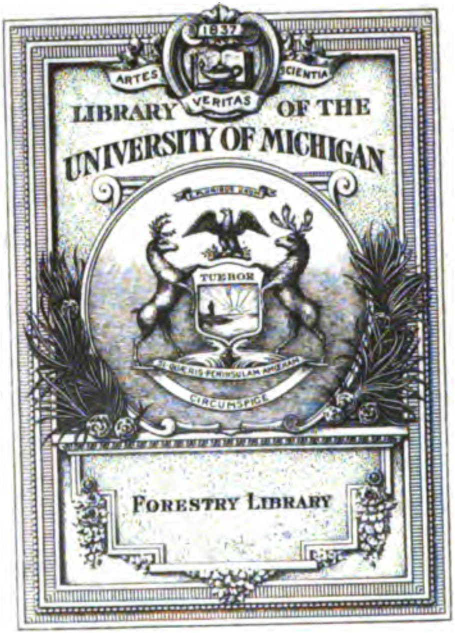
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University of the State of New York

BULLETIN

OF THE

New York State Museum

VOL. 5 No. 20

JUNE 1898

ELM-LEAF BEETLE

IN

NEW YORK STATE

PREPARED BY

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Acting State Entomologist

ALBANY
UNIVERSITY OF THE STATE OF NEW YORK
1898

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PREFACE

This bulletin was prepared, first to bring prominently before the public the very destructive nature of this imported insect, and second to demonstrate that it can be controlled without great expense, provided intelligent direction is given to the matter.

The life-history and habits of this beetle have been given somewhat in detail because unless they are thoroughly understood, it is very easy to adopt means that are only partially successful or futile. In order to give the bulletin a more practical value, short accounts have also been included of three other insects, which, working with the elm-leaf beetle, have aided greatly in ruining many noble elms.

In the portion devoted to remedies prominence has been given to the cost of spraying per tree, the proper apparatus and the time and manner of application. It is surprising to see what mistakes some men make in dealing with insects and how they cling to methods of no value. To offset this tendency, two of the more common fallacies are mentioned and their futility shown.

E. P. Felt

Albany, N. Y., 21 *June*, 1898

THE ELM-LEAF BEETLE IN NEW YORK STATE

Galerucella luteola Müller

Ord. Coleoptera: Fam. Chrysomelidae

This imported insect has committed such extensive injury to the elms in the cities and villages along the Hudson river that it is worthy of extended notice. The residents of places where this pest has established itself have repeatedly observed the grubs working on their elms and in many instances have seen two or even three crops of leaves destroyed in a single season without taking steps toward the protection of the trees.

The causes for this condition of affairs are not hard to find, as the majority are inclined to trust in providence and hope that the ravages of the insect will not be as severe the next season. Many others see the grubs at work on the underside of the leaves but not being quite sure of the best method of controlling them, and as there is no way of doing this without labor, they usually make no effort to subdue the pest.

Bad reputation of its family. This beetle is a member of the large, leaf-eating family of *Chrysomelidae*, which comprises a number of our most injurious insects. It includes such well-known pests as the asparagus beetle, *Crioceris asparagi* Linn., the Colorado potato beetle, *Doryphora 10-lineata* Say, the 12-spotted Diabrotica, *D. 12-punctata* Oliv. and the striped cucumber beetle, *Diabrotica vittata* Fabr., all well-known insects against which perpetual warfare must be waged. Another member of this family, the cottonwood-leaf beetle, *Lina scripta* Fabr., recently inflicted serious damage upon the large basket industry in the willow growing districts about Syracuse, Rochester and other localities in that part of the state. Judging from the well-known records of its allies, we may expect that the elm-leaf beetle will continue to be very destructive.

Inaction means death to the elms. The elm-leaf beetle was known in Albany in 1892, probably having made its way to the city a year or two earlier, and since that time its ravages have become more and more serious, until in 1897 most of the numerous European elms along our streets were completely defoliated once, the second growth of foliage was seriously injured, and some trees had their third set of leaves attacked. This condition of affairs was observed in Albany and Troy and was true to a greater or less extent in many other places along the Hudson river. The leaves are the breathing organs of a tree. Their removal or destruction weakens it seriously, and to have that occur even once a season for successive years, means the early death of the unfortunate elm. The number of magnificent shade trees killed by this insect in Albany, since its advent, may be estimated at over a thousand, and had not the city taken action to protect the elms many more would have succumbed in the next year or two.

It is useless to hope that another season the pest may not be as destructive. It shows a remarkable vigor and prolificacy in our climate. At Washington, D. C., it has been known for a long series of years and still is very injurious. In New Jersey, New York city, New Haven, Conn., and other localities it has been found necessary to spray the trees with a poisonous mixture in order to avert serious injury. Parasites, diseases of various kinds and predatory enemies seems to have little effect in reducing its numbers. The valley of the Hudson river as far north as Saratoga is now included in the same life zone as that of the latter places named.

Distribution. This insect is common over a large part of Europe, but it is injurious only in the southern portions of Germany and France and in Italy and Austria. The records of the earlier entomologists indicate that the beetle must have made its way to this country about 1834, because in 1838 it was reported as very injurious to elms in Baltimore, Md. It is now found from Charlotte, N. C., to north of Salem, Mass. Up to 1896, so far as known, it was limited to territory east of the Appalachian chain of mountains. In that year it was found established at Elm Grove and Wellsburg, W. Va., by Dr Hopkins of the Agricultural experiment station of that state. Its progress up the Hudson is interesting to follow, indicating, as it does, the distribution of the beetle along the lines of travel. In 1879[a] it was abundant and destructive at Newburg; 12 years later it was reported to this office from Poughkeepsie, in 1890 from Hudson, in 1891 from New Baltimore and in 1892 it had reached Albany and Troy. It was found at Mechanicville in 1896 by Dr L. O. Howard, of Washington, D. C. That same year the larvae were abundant at Averill Park in the town of Sand Lake about seven miles southeast of Troy, the beetles evidently having been transported thither by the numerous electric cars running to that station. In a similar manner it has spread over a large portion of Connecticut and into Rhode Island. It had made its way up the Connecticut valley to Springfield by 1891, and to Amherst by 1895. The latter year it was found by Dr Howard at Millers Falls and was reported to him then at South Vernon, it having crossed the New Hampshire line. It has also been reported from north of Salem, Mass., and at Middlebury, Vt.—two localities distant from others where it has been found.

The above record indicates most clearly that this pest has not made its way to all portions of the state where it may be expected to thrive. The climate of the upper austral life zone seems to agree with the insect, judging from the number of broods and its abundance in Albany and vicinity. The area within the state embraced by this zone has been represented on plate 4, in the *11th Report on the insects of New York*. Briefly, it embraces Long and Staten islands, the valley of the Hudson river north about to Saratoga and a large portion of the northwestern and central part of the state adjacent to the great lakes and including Oneida, Cayuga, Seneca lakes and neighboring bodies of water. This insect will probably make its way along the lines of travel to most of the cities and larger villages lying within the above limits. The beetle having become established at localities not yet included within this zone, indicates that it may have an even wider range, although climatic conditions will probably prevent its becoming destructive.

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[a] Unfortunately most of these dates indicate only the time when the ravages of the insect were serious enough to attract the attention of some one, and so only approximately the year of its arrival.

Description. The work of this pest is so striking as to excite the attention of even the most casual observer. The majority have little idea of the appearance of the insect in its various stages and but faint conception of its life history. In order to control the pest it must be recognized and its nature understood to a certain extent.

The parent insect may be recognized by aid of the colored figure (pl. 1, fig. 2), although care should be taken not to confound it with the striped cucumber beetle, *Diabrotica vittata* Fabr., which it resembles in a general manner. The elm-leaf beetle is about ¼ of an inch long with the head, thorax and margin of the wing covers a reddish-yellow. The coal black eyes and median spot of the same color on the head are prominent. On the thorax there is a median black spot of variable shape and a pair of lateral ovoid ones. The median black line of the wing covers is separated from the broad lateral stripes of the same color by greenish-yellow. The elytra are minutely and irregularly punctured, bear a fine pubescence and at the base of each elytron there is an elongated black spot in the middle of the greenish-yellow stripe. The markings are usually constant in the adult, but the color is quite variable during life and changes more or less after death. In some beetles emerging from winter quarters, the conspicuous greenish-yellow stripes of the wing covers are nearly black. The antennae are a golden yellow with more or less brownish markings. The legs are yellowish with the tibiae and tarsi marked with brown. The under surface of the head and prothorax is yellowish, that of the metathorax and abdomen black.

The orange yellow eggs are deposited in irregular rows side by side, forming clusters of from five to 26 or more on the under surface of the leaf. Each egg is somewhat fusiform, attached vertically by its larger end, with the free extremity tapering to a paler, rounded point (pl. 1, fig. 3). Under a powerful lens, the fine reticulations of the egg shell are easily seen.

The recently hatched larva is about $\frac{1}{20}$ inch long, with the head, thoracic shield, numerous tubercles, hairs and legs jet black. The integument between the tubercles is a dark yellow. The tubercles are so large and the hairs so prominent that the prevailing color of the larva at this stage is black. As the larva increases in size and molts, the stiff black hairs become less conspicious and the yellowish markings more prominent (pl. 1, fig. 4) until the last stage. A full grown larva is about ½ inch long, more flattened than in the earlier stages, with a broad yellow stripe dorsally and a narrower stripe of the same color on each side, the yellow stripes being separated by broad dark bands thickly set with tubercles bearing short, dark-colored hairs. The dorsal yellow stripe is broken on each side by a subdorsal row of dark tubercles, which increase in size posteriorly. The lateral yellow stripe includes a row of prominent tubercles with dark tips bearing short hairs of the same color (pl. 1, fig. 5). The predominating color of the ventral surface is yellow.

The pupa is bright orange yellow, about $\frac{1}{5}$ inch long, and with a very convex dorsal surface which bears transverse rows of stout, inconspicuous setae.

Life-history. In order to control this insect successfully it must be known and its habits understood. Trite though the preceding may appear, I have noticed men in several places spraying for this pest and doing no execution, for the simple reason that they did not understand the fundamental principles involved in fighting insects. In one case the trunk of the tree was sprayed while the grubs were on the leaves, and in the other they used paris green and water when kerosene emulsion or whale oil soap solution should have been employed.

The beetles pass the winter in attics, sheds or out-houses and in various sheltered places. With the advent of warm weather in the spring, they emerge from their retreats and may be found on the walks during the sunny portion of the day or upon the windows of houses, vainly trying to escape. Even when writing this (May 12th) numbers of these beetles are to be seen on the office windows of the fourth story of the capitol, thus showing to what a height they will fly in seeking secure winter quarters. On the appearance of the leaves, the last of April or the early half of May in this latitude, they fly into the trees and eat irregular holes in the foliage (fig. 2). After feeding some time, and pairing, the orange yellow eggs are deposited on the under surface of the leaves in clusters of about 5-26. The duration of the egg stage in July averages about five days, in cooler weather it may be longer. Feeding and oviposition continue for several weeks in the spring, probably from four to six. During this time the beetles consume a large amount of foliage, which is evidently necessary for the development of the eggs, as clusters are laid every day or two until the full complement is discharged, which is in the neighborhood of from 431 to 623. As there seems to have been no attempt, at least in this country, to determine the prolificacy of this insect, the following record may be of interest. On May 31st, two large females were taken and isolated with plenty of food. On June 1st, one had deposited four clusters, comprising 42 eggs; on the 3d, a cluster of 18; on the 6th, clusters of 21 and 26 eggs; on the 8th, clusters of 26 and 4; on the 9th, a cluster of 27; on the 10th, clusters of 3 and 31; on the 13th, clusters of 3, 7, 8, 11, 15 and 19; on the 15th, clusters of 14 and 27; on the 16th, a cluster of 30; on the 17th, a cluster of 32; on the 19th, clusters of 10 and 26; on the 20th, a cluster of 36; on the 21st, clusters of 6 and 25; on the 22d, clusters of 4 and 31; on the 23d, clusters of 1, 2, 7, 11 and 13; on the 27th, clusters of 13, 21 and 32; on the 28th, clusters of 4 and 17, making a total of 623.

The other had deposited on June 1st, two clusters containing a total of 29 eggs; on the 3d, clusters of 9, 9 and 14; on the 6th, another of 18; on the 8th, clusters of 15 and 20; on the 10th, a cluster of 20; on the 11th, a cluster of 23; on the 13th, clusters of 11 and 13; on the 14th, a cluster of 31; on the 15th, a cluster of 16 and 5 scattering; on the 16th, a cluster of 28; on the 18th, clusters of 26 and 30; on the 20th, clusters of 2 and 6; on the 21st, clusters of 3 and 18; on the 22d, clusters of 2 and 20; on the 23d, a cluster of 27; on the 27th, clusters of 5, 7, 9 and 15, making a total of 431.

The continued oviposition and the prolificacy of the beetles is strikingly shown in the above record. They were abroad in numbers by May 12th and oviposition began about the 25th, so that the record of these two individuals is probably lower than the normal as they may have deposited several clusters of eggs before being captured. They were both supplied with fresh leaves from day to day and the eggs removed and counted as soon as detected. The female producing the smaller number of eggs was confined in a small, corked vial, while the other enjoyed the freedom of a jelly tumbler. The difference in conditions undoubtedly had some influence on egg production and the protection from unfavorable weather conditions enabled the beetles to approximate the maximum quota of eggs. The record is of great value since it shows most clearly how long oviposition may be continued by a single individual and the desirability of spraying early in the season for the purpose of killing the beetles.

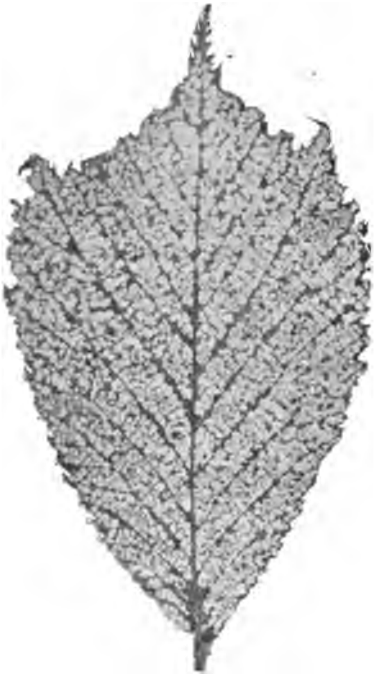

FIG. 1.—Work of elm leaf beetle larvae.

The young grubs emerge from the eggs early in June or in about five or six days after oviposition. and soon begin to feed on the under surface of the leaves, producing the familiar skeletonized appearance well represented in figure 1, which is caused by their eating the softer under part, leaving the upper epidermis and the veins. The result of their feeding is so characteristic that it is easy to detect their presence by the semitransparent places in partly eaten leaves and by the skeletonized appearance of the foliage which has been more severely attacked.

The larvae complete their growth in from 15 to 20 days in summer (in cooler weather the time is extended), become restless, forsake the leaves and descend the limbs and trunks of the tree to a greater or less extent, seeking proper shelter for pupation. In warm July weather seven days are passed in this state, in September the time is extended to 12 days and in October to 24. The descent of the larvae of the first brood usually occurs in Albany the latter part of June,—in 1896 some were observed descending May 19, and beetles of the second brood were taken May 30. The oviposition of the second brood of beetles begins about the middle of July. From that date until late in the autumn, it is possible to find the eggs of this insect most of the time in some part of the city. The beetles are naturally more attracted by a fresh growth of foliage and it is on the trees throwing out a second or third crop of leaves that the eggs of the later generations are found most abundantly. Most of the second brood of larvae complete their growth about the middle of August, transforming to adults the latter part of the month. If there is an abundant food supply a third generation is produced. In 1896 numerous eggs were found on elms in Troy the first part of September, and the same was probably true in Albany, as indicated by the large numbers of full grown larvae descending certain Scotch elms, which had been practically uninjured in the early part of the season, near the middle of October.

This latter occurrence shows most conclusively, that the larvae must be able to develop on old leaves. The persistent breeding of this insect late in the autumn is shown by the presence of full grown larvae on trunks of elms October 31 and the finding of living pupae November 7, 1896, and on the still later date of November 16, 1897.

Number of generations. The detailed observations of the past two years have established beyond question the presence of two well marked generations and the occurrence of an incomplete third brood under favorable conditions at both Albany and Troy. In these two cities the insect has continued breeding so long as the elms afforded sustenance. This is the more remarkable since Dr Smith records but one brood a year, or one and a partial second at New Brunswick, N. J., a point about 150 miles to the south. As is well known, most insects are more destructive soon after their introduction than in later years. This may be accounted for by the fact that in time native parasites, diseases and other natural checks gradually assert their power upon new comers. An insect's freedom from natural enemies might have some effect upon its prolificacy, and possibly upon the number of generations. It will not only be of interest, but of great practical importance to ascertain by observations whether this beetle continues to produce two or three generations yearly in this latitude.

Habits of beetle and larvae. Certain habits of this insect are of great value when the problem of controlling it comes up for solution. Its hibernation affords no vulnerable point as the beetles are then too scattered to admit of effective work against them. In the spring they feed on the young leaves for two or three weeks and when abundant may cause considerable injury. The irregular round holes seen in the young leaves (fig. 2) are an indication of the presence of this pest. Under exceptional circumstances the beetles may eat the under surface of the leaves, refusing the veins and tough upper epidermis. This only occurs when the foliage is unusually hard and dry.

One habit the adult insect possesses, which is of much importance, is its disinclination to fly a great distance. The instinct within this beetle to remain near one spot is so marked that it spreads very slowly indeed. This is clearly shown in its taking seven years to make its way in numbers from the point where it established itself first in this city to Washington park, a distance of less than one and one half miles. I have repeatedly seen European elms badly defoliated and within 50 feet others of the same species would be hardly affected. In the past three years the insect made its way along certain rows of European elms in Albany at the rate of about a block a year.

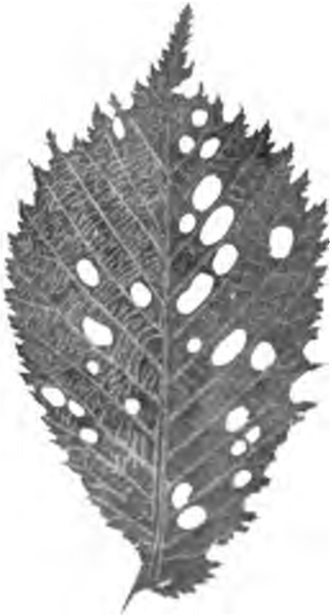

FIG. 2. —Leaf showing holes eaten by elm-leaf beetle

The larvae are very rarely found on the upper part of the leaf, but they occur on the under surface of the leaves and feed there almost exclusively. It is also evident that in most cases the trees are attacked near the top, probably because the foliage of the upper portion of the trees is more tender and clean. This is well shown on plate 2, where the dead tips are high, showing conclusively the preference the beetles have for the younger leaves.

After attaining their growth, the larvae forsake the leaves and may be found crawling along the limbs and trunk. If the tree has comparatively smooth bark, a far greater portion make their way to the ground, in search of proper shelter while passing through the pupa stage, than if a rough bark, which affords numerous secure crevices in which the final changes may be effected. At this time the trunks of infested trees present an interesting sight as thousands of the grubs crawl up and down the shaggy bark. Occasionally their numbers are so great as to give a distinct character to the surface they are moving over, presenting a peculiar grayish yellow mass of motion enlivened here and there with an orange yellow pupa. A few days later the light yellow pupae are more numerous on the trunk and around the base of the tree and adjacent shelter, where they may be found in golden layers nearly an inch in depth interspersed here and there with a dark larva. It will be found that many larvae do not descend the older trees but take refuge in the crevices of the bark, or, if there are overhanging limbs, they may drop in numbers from the tips of the branches. Many are content to transform in the gutters, others seek shelter in the crevices of the sidewalks and large numbers cross wide spaces and pile themselves up against a wall, fence or around any sheltering bush or weed.

SPECIES OF ELMS ATTACKED

It will be observed in most localities that the American elm, *Ulmus Americana*, is comparatively exempt from the attacks of this insect. Sometimes the beetles will make their way from adjacent European elms and seriously injure the American species and, after they have once become established, the but partially migratory habit of the beetle ensures attack for a few successive seasons at least. In most cases the English elm, *Ulmus campestris*, and the Scotch elm, *Ulmus montana*, suffer most seriously from the pest, while our native species are but little affected. This was very noticeable in Troy and Lansingburg. In the former, European elms are numerous and the work of the elm-leaf beetle is conspicuous over a greater part of the city, but as one proceeds northward into Lansingburg the American elms abound almost to the exclusion of the foreign species and evidences of this pest are comparatively rare. Again, in 1895 the American elms of Albany showed very little injury by the insect.

The next year trees here and there gave evidence of a serious attack and in 1897 a much larger number of the American elms was seriously injured than in the preceding year.

No species of elm grown in this country is exempt from attack although there is considerable variation in the degree of injury inflicted upon them. The relative liability to attack is apparently a variable quantity in different localities. According to Dr Howard's observations, the American elm suffers more from the insect than does the Scotch, the English species being the favorite, while in both Albany and Troy the injuries were about equal to the English and Scotch, the latter suffering more in many instances, while the American elm was eaten to a much less degree.

AN ASSOCIATED INSECT

The elms, particularly the European species, in Albany, Troy and other places along the Hudson river are most unfortunate in suffering from the attacks of another imported insect, which is known as the elm tree bark-louse, *Gossyparia ulmi* Geoff. The pest was first discovered in this country at Rye, Westchester county, N. Y., in 1894, on the nursery stock of Mr Charles Fremd. It is now known to occur in a number of localities in the Hudson valley, being generally distributed over Albany, Troy and adjacent towns. It has also become established in the vicinity of Boston and at Amherst, Mass., and Burlington, Vt. Other localities are Washington, D. C.; Michigan Agricultural College; Carson City, Nevada, and Palo Alto, California.

Injuries and characteristics. The injurious nature of this bark-louse in our latitude has been abundantly demonstrated the past few years in conjunction with the work of the elm-leaf beetle. The affected trees are easily recognized in midsummer by their blackened appearance, caused by a growth of the fungus, *Coniothecium saccharinum* Peck, in the honey dew covering the foliage, limbs and the ground beneath. In sunlight, the minute drops of the secretion may be seen falling in showers from the clusters of insects, giving an idea of what a drain this species is upon the vitality of the elm. The limbs which have harbored this bark-louse for a few years begin to die, the tree itself shows signs of weakness, and when it is attacked by both the elm-leaf beetle and this bark-louse its destruction follows in a few years.

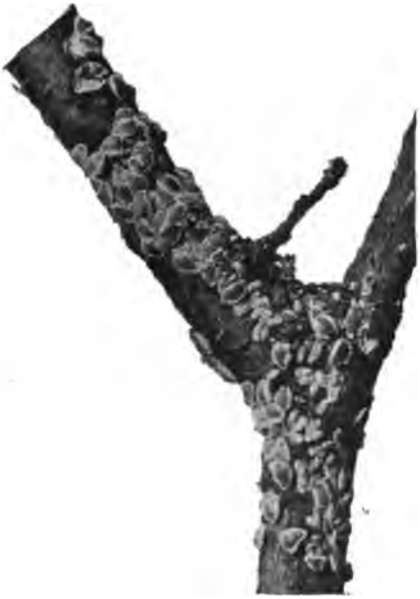

FIG. 8 — Females of GOSSYPARIA ULMI (slightly enlarged)

Description and life-history. The adult females are very conspicuous and may be found on the under side of the smaller branches, frequently clustered in masses and appearing not unlike certain lichens. Each at this time is about $\frac{1}{10}$ inch long, oval in outline, with the extremities slightly pointed, and if crushed causes a reddish stain from the contained ova. The body is surrounded with a mass of white, woolly secretion and the segmentation is also indicated by the same substance, as shown in the accompanying figure. The minute yellow young make their appearance early in July and soon settle for a time on the greener twigs and along the principal veins of the leaves. In the autumn the back of the partly grown bark-louse is covered with spiny processes secreting a white waxy matter. At this time most of the insects forsake the leaves and settle for the winter in crevices of the bark. In the early spring the females molt for the last time, and the males spin their oval cocoons (fig. 4). The delicate, four-winged reddish male is rarely seen although of particular interest from its presenting a partially developed form known as the pseudimago.

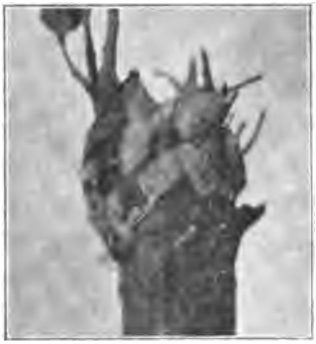

FIG. 4.— Cocoons of male (three times natural size)

Means of distribution. As the slender males only are winged, the insect is dependent largely upon various agencies for its distribution. It has most probably been carried to Nevada, California and other distant localities on infested nursery stock, but this does not explain its general occurrence in such cities as Albany and Troy. In these two places, at least, the distribution appears to have been largely effected by the aid of the English sparrow and other birds, since the active young could easily crawl upon the foot of a bird and thus be transported to another tree. Other insects may also transport them to a certain extent and some, falling with the leaves, might successfully make their way up another tree, but the chances are against the latter method.

SECONDARY ATTACKS BY INSECTS

It is well known to students of nature that an infeebled tree apparently invites attack by certain insects which seem to find in the unhealthy tissues conditions peculiarly fitted for their development. The ravages of the elm-leaf beetle have encouraged certain of these pests to a marked degree. One of the most common and injurious is known as the pigeon Tremex, *Tremex* *columba* Linn. This insect is a magnificent four-winged fly about 2 inches long, with a wing spread of 2½ inches, and a prominent horn at the extremity of the abdomen, hence the common name of horn-tail. It may be recognized by its cylindrical dark brown abdomen with yellow markings as represented in figure 5.

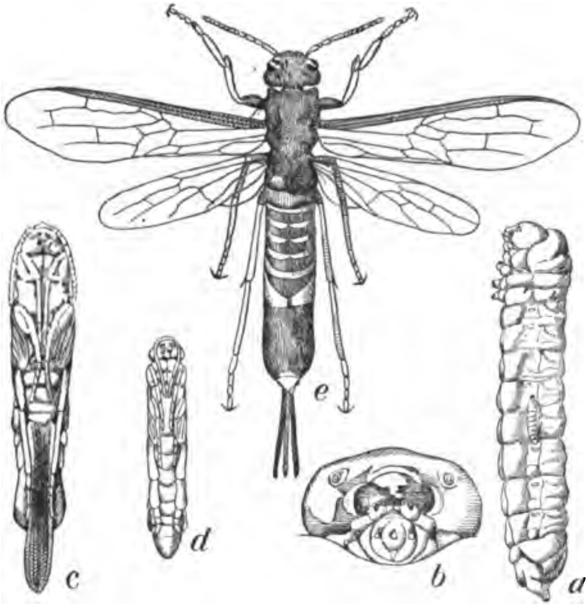

Fig. 5. Tremex columba: *a*, larva showing the Thalessa larva fastened to its side; *b*, head of larva; *c*, pupa of female; *d*, male pupa; *e*, adult female — all slightly enlarged

The female deposits her eggs in the trunks of sickly trees, where its larvae run large cylindrical burrows. Many elms in both Albany and Troy show numerous holes caused by this insect. This borer has a deadly parasite in the lunate long sting, *Thalessa lunator* Fabr. This beneficial insect is of great aid in keeping the Tremex under control. In the trunk of one small elm I found the remains of 13 ovipositors. In their efforts to reach the numerous borers in the tree, the females had driven their long ovipositors so far into the wood that they were unable to withdraw them.

Another insect which infests debilitated elms is known as the elm borer, *Saperda tridentata* Olivier. The larvae of this beetle run their burrows under the bark and in the sap wood of the trunk, not many penetrating to a greater depth than an inch. Their burrows may become so thick as to girdle trees two or three feet in diameter. An infested elm may be recognized by the patches of unhealthy bark—in case of a bad infestation large pieces become loose and scale off easily. The beetle is usually less than ½ inch long, and of a dull slate color, with the thorax and wing covers margined with dull orange (fig. 6).

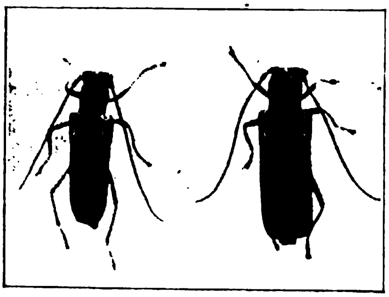

FIG. 6.—SAPERDA TRIDENTATA (twice natural size)

NATURAL ENEMIES OF ELM-LEAF BEETLE.

The natural checks which serve so well to keep thousands of insects under control which otherwise would be very destructive, are unable to reduce the numbers of this beetle to a relatively harmless figure. One of the more important natural agents is the fungus, *Sporotrichum entomophilum* Peck, which has been observed developing on many beetles in this city. Like the disease of the chinch-bug, caused by the allied fungus, *Sporotrichum globuliferum* Speg., the one attacking the elm-leaf beetle requires moist atmosphere for its development. Beetles in close breeding jars or those found under the bark of trees and similar damp places succumbed readily to the disease. On account of the climatic conditions not being ordinarily favorable to the rapid growth of this fungus, it has a relatively slight value as a natural check upon the elm-leaf beetle.

Several insects are known to prey either on this pest, its pupa or larva. Three beetles, *Platynus punctiformis* Say, *Quedius molochinus* Grav. and *Chauliognathus marginatus* Fabr., feed on this species as recorded by Riley. A fly, *Cyrtoneura stabulans* Fall., destroys many pupae in Washington. In this latitude the half-grown larva of *Podisus spinosus* Dallas has been observed with an elm-leaf beetle grub in its extended beak, and it probably preys extensively on the larvae, since in Washington all stages are known to attack it. Unfortunately this beneficial species is not abundant, though it is to be hoped that the large food supply will lead to an increase in its number. A small capsid, *Camptobrochis grandis* Uhler, sucks the eggs. Larvae of lace-wing flies, also called aphis lions, are frequently found on leaves with the young of the elm-leaf beetle, and are reported by Riley to feed on both eggs and larvae. Mites have been seen near egg clusters that had suffered injury. In the southern portion of its range, this insect finds an enemy in the praying Mantis, *Mantis Carolina* Linn.

Although I have seen nothing of the kind in this vicinity, one gentleman affirms most positively that the English sparrow feeds on the elm-leaf beetle larvae, he having repeatedly observed it picking them off the trunks of the trees. If the sparrow has this habit, it offsets to a certain extent the many bad features possessed by this bird.

REMEDIES

Undoubtedly the most satisfactory method of controlling this insect is found in poisoning the foliage. The objection heretofore urged against this means has been the expense involved, and it still applies to a certain extent in the case of the private individual with but a few trees to care for. Aside from the cost of the necessary apparatus, the operation of spraying even large shade trees is not so expensive as is commonly supposed and on the other hand valuable results may be obtained with a comparatively inexpensive outfit, although the cost per tree may be increased.

Cost of spraying elms. I have taken some pains to ascertain the precise cost of spraying per tree in the hope of encouraging those to whom this would be a serious item. It is pleasant to record that the expense is much lower than I had supposed. Dr Smith, of the New Jersey agricultural experiment station, has kindly supplied the following data. The elms on the college campus at New Brunswick are 50 to 75 feet high and were sprayed at odd times by the janitors, it requiring about an hour for two with force pump, tank and ladders to treat one tree. The poison necessary for each spraying was worth about six cents. It will thus be seen that the cost per tree would be between 36 and 56 cents, varying with the price of labor. In the city of New Brunswick the trees were sprayed at a contract price of one dollar for the season, the understanding being that they were to receive three treatments if necessary. The contractor prepared the outfit, furnished the material, did the spraying at the price mentioned and had a neat margin remaining.

Mr Kirkland, Assistant state entomologist of Massachusetts, has kindly supplied me with the following figures. A grove of over 200 red and white oaks ranging in height from 40 to 70 feet were sprayed once at an expense of 49 cents per tree. In this instance arsenate of lead was used at the rate of 20 lbs to 150 gallons of water, a considerably stronger mixture than would be necessary for the larvae of the elm-leaf beetle. In addition, he estimated the expense of spraying smaller trees, 20 to 40 feet high, at 15 to 20 cents per tree.

The cost of spraying the elms in Albany this season, aside from wear and tear of the apparatus, is considerably less than the figures above given. The trees present a wide range in size, although the majority are from 50 to about 70 feet in height. Taking them as they come, Mr Lewis has succeeded in spraying them once at the low cost of about 15 cents per tree. This is largely due to the excellent apparatus, to be described later, and is a most encouraging feature of the work. It is hoped that these figures will induce private individuals to provide protection for their trees, either by doing the spraying themselves or else by hiring some capable party.

Proper apparatus. In order to do this work successfully one must possess a force pump capable of throwing a stream some distance, a number of feet of hose and a nozzle that will discharge a rather fine spray. There must also be something to hold the poisonous mixture, while a ladder facilitates the work greatly.

One of the best arrangements for hand work is most probably found in the spraying outfit mounted on wheels so that it can be readily moved from place to place (Plate 5). In most cases this takes the form of a box or barrel to which a force pump is firmly attached, and either provided with wheels or else designed to be placed in a wagon. In spraying tall trees 25 to 50 or more feet of ¼ or ½ inch hose should be provided, while the addition of a brass or iron and brass extension 10 to 25 feet long adds materially to the value of the apparatus. It is also necessary to have a good nozzle that will not clog, but produce a fine spray and that can be quickly adjusted to throw a coarse spray some distance if necessary. Such an outfit is of great service to any individual having considerable spraying to be done and undoubtedly it could be used to advantage by those desiring to make a business of spraying in a small way, as for example the treating of trees here and there for those in cities desiring their trees sprayed and not willing to purchase the necessary apparatus.

In the extended work against this insect conducted by cities and villages, it is desirable to have apparatus that will admit of more rapid work. This has led to the refitting of retired fire engines and the designing of more or less cumbersome outfits for this purpose. In all cases these makeshifts have been successful, although they are not so satisfactory in operation as those specially fitted for the purpose. Probably the best apparatus yet designed for spraying trees is that constructed under the direction of Dr E. B. Southwick, entomologist of the department of public parks of the city of New York, and which is the form used in Albany. The whole outfit is represented in plate 4. It consists of a 'Daimler' gasoline motor operating a Gould force pump—the motor and pump weighing but 300 pounds can be placed in the bottom of a spring wagon along with the 100-gallon tank containing the poisonous mixture. This motor has the advantage of being almost noiseless in operation and is scarcely noticed by passing horses. It is very inexpensive to operate, as a gallon of gasoline is sufficient for a day and it requires so little attention that a tyro can run it. The smallest size Gould 3-piston pump is the one used with the motor, although Dr Southwick now recommends a larger one in order to utilize the power more fully. The motor costs $250 and the pump about $50. They can easily supply four lines of hose, although in Albany not more than two can be used to advantage in most places.

In addition to the lines of hose and other requisites, Mr P. C. Lewis, of Catskill, N. Y., who is in charge of the spraying in this city, has several interesting devices for saving time and increasing the efficiency of the work. He has designed a modified stepladder, about 16 feet high with platforms for two men and on two of its legs there are small wheels which permit ready removal from place to place. It is so constructed that it can be folded up and drawn behind the wagon when some distance is to be traversed. He also has in constant use a metal extension 25 feet long. The lower portion is composed of larger tubing, thus making it stiffer and at the same time rendering it easier to handle because the greater part of the weight is near the operator. This extremely long extension is suspended by a rope from the top of the modified stepladder in such a manner that the man has only to guide the stream. This arrangement does away with all climbing. In many instances the huge steps are placed in the middle of the street and the trees on both sides sprayed either from the steps or the ground.

Time and manner of spraying. Though it is easy to state the proper time to spray, in many cases it is exceedingly difficult to have the recommendations properly carried out. As has been stated, the beetles feed on the young leaves for a considerable time before any eggs are developed and continue feeding for a day or more between the deposition of each cluster. If the partly unfolded leaves are sprayed in the early spring, the beetles can be killed and the production of eggs prevented. This is very desirable, for if at all numerous the beetles injure the foliage considerably. In the second place the mischief is checked at its inception. To accomplish this end, Dr Smith recommends the use of one pound of paris green or london purple to 100 gallons of water. To avoid any danger of injuring the foliage, it is advisable to add also one pound of quicklime to neutralize any soluble arsenic that might be present. Two quarts of cheap molasses added to the mixture will make it adhere longer to the leaves.

In most cases it will also be necessary to spray again at the time the young larvae begin their work, although after the insect has once been brought well under control in a locality, it is possible that a single thorough spraying each year for the beetles may be sufficient. This second spraying should occur at the time the young are beginning to hatch, which in this latitude is about the first week in June. In order to be successful, the poison must be applied to the under surface of the leaves. The reason for the latter statement is found in the fact that only very exceptionally do the larvae feed upon the upper surface of the foliage or even break the upper epidermis, consequently it is impossible to poison them unless the arsenic be placed on the under surface. As the larvae succumb more readily than the beetles to the effects of poison, but one pound of paris green to 150 or 200 gallons of water is needed for the second spraying.

The necessity for subsequent sprayings is determined largely by the manner in which the work has been done. Much depends upon the man who holds the nozzle, even though he be under the eye of one who understands the business. The mixture should be applied evenly in a rather fine spray and so far as possible to every leaf. If the poison be applied thoroughly and at the right time, two sprayings should be ample to keep the beetle under control. Otherwise it may be necessary to spray for the second and even third broods. The proper time for later arsenical sprayings must be determined by observation. In Albany and Troy the spraying for the second brood should be done about the latter half of July.

A PALLIATIVE MEASURE

It frequently occurs that for some reason or other spraying with poison is not or can not be resorted to readily. The habits of this insect are such that large numbers can be destroyed at times with little labor, as has been pointed out year after year. It is well to understand that any such measure is not a remedy for the evil in the true sense of the word, it is simply a palliative. Everyone interested in the welfare of their shade trees should at least destroy the thousands of larvae and pupae found on the trunk or around the base of infested elms. If the base of the trees, their surroundings and other adjacent shelters be thoroughly drenched with boiling water, or sprayed with kerosene emulsion, kerosene or similar preparations, thousands of these insects would be killed. As it requires at least five days for the larvae to transform through the pupal stage to beetles, this operation need not be performed more frequently than that, in order to ensure the destruction of all that pupated within reach of such measures. The nearly simultaneous descent of the grubs is very favorable to this method of checking the insect and reduces the necessary labor to a minimum. To make this method more effective, it has been recommended to inclose a limited smooth area, preferably cemented, around each infested tree with boards so arranged as to prevent the larvae escaping to shelters where they could be less easily destroyed. In the case of small trees with relatively smooth bark and no overhanging limbs, such an inclosure might be advisable, but it would hardly pay to treat larger trees thus on account of the large number of larvae pupating in the crevices of the bark or else dropping from the tips of overhanging limbs. The great objection to fighting the insect at this stage is found in the fact that the destruction has already been accomplished, but even this is much better than allowing the insect to go unchecked because it has some influence upon the future abundance of the beetle.

USELESS MEASURES

Although the life-history of this beetle is well known by entomologists at least, it is surprising how people will cling to some false idea, gained they know not where, of the proper method of fighting this or some other insect.

One of the most persistent of these fallacies is that cotton placed around the trunk will protect a tree from the elm-leaf beetle. Under certain conditions a band of cotton, tar or other substance will protect trees from some insects, but never from the elm-leaf beetle. It should be understood that the parent insect flies up into the tree, feeds for a time and then lays the eggs from which the grubs emerge and commence their injurious work. The band can not have the slightest influence in protecting the elm. It is only when the grubs have become full grown that they are found on the trunks and then only for the purpose of seeking shelter on the ground during pupation. If a band of any kind blocks the way to the ground, they may transform on the tree or even in the meshes of the cotton band and fly away later. In case a band of tar is used, some of the grubs will be caught on its surface by accident, but the number will not be large enough to pay for the trouble incurred.

Another so-called remedy for the elm-leaf beetle consists in boring a hole to some depth in the trunk, nearly filling it with sulphur or other preparation and then inserting a plug. This method of treatment or some modification of it, is being brought forward every few years as one of the 'sure cures.' The destruction by the elm-leaf beetle has encouraged at least one unscrupulous firm, known in 1895 as the Elm inoculation company, to advertise some modification of this method as a sure cure for the pest. They treated many elms in Connecticut, 150 for one man in Westchester county, N. Y., charging 50 cents or more per tree. Chemical analysis showed their secret preparation to be nothing of value. This or any similar treatment may well be regarded with suspicious eyes by any would-be investor. It is hardly necessary to add that such a remedy has no basis in scientific fact and any similar recommendations should not be heeded, unless they come through channels whose authenticity can not be doubted.

REMEDIES FOR ASSOCIATED INSECTS

As the elm bark-louse belongs to that large order of insects, the Hemiptera, which take food only by suction through a fine proboscis from the underlying tissues, it is easily seen that a poison applied externally to the tree, as for example paris green, would have no effect on the insect. The best remedy is found in the use of one of the contact insecticides, preferably kerosene emulsion or whale oil soap solution, which should be sprayed on the under surface of infested limbs and foliage, at the time the tender young are appearing. Kerosene emulsion may be prepared by dissolving one half pound of hard soap in one gallon of boiling water and while yet hot add two gallons of kerosene and emulsify thoroughly by passing it rapidly through a force pump until it is white and has a creamy consistency. For the young, one part of this emulsion to ten parts of water should be effective. the whale oil soap solution may be used in the same manner if one pound of the soap be dissolved in four gallons of water. If desired these preparations could be applied in the autumn after the leaves have dropped, but the solutions should be about four times stronger. Small trees may be cleaned by the use of a stiff brush, which might be made more effective by dipping it in one of the above solutions from time to time.

Preventive measures are of much more importance against borers than any remedies that can be applied. The trees should be kept in as vigorous a condition as possible and careful watch maintained for the first signs of boring, which is indicated by the detached grains of wood popularly termed 'sawdust.' When indications of their presence are found the larvae should be dug out if possible. A badly infested tree should be cut down and burned in order to prevent the development of the insects and the adults making their way to other trees.

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EXPLANATION OF PLATES

Plate 1

Fig. 1 Elm leaves showing eggs and work of young larvae.
Fig. 2 Elm-leaf beetle (x2).
Fig. 3 Vertical and lateral view of eggs, very much enlarged.
Fig. 4 Young larva, very much enlarged.
Fig. 5 Full grown larva (x5).

Plate 1a

Fig. 1 Foliage of European elm showing method of work of beetle and larva — natural size.
Fig. 2 Adult beetle.
Fig. 3 Egg mass.
Fig. 4 Young larva.
Fig. 5 Full-grown larva.
Fig. 6 Mouth parts of full-grown larva.
Fig. 7 Pupa.

Plate 2

Work of elm-leaf beetle on Elm street, Albany, taken 15 June, 1898.

Plate 3

Work of elm-leaf beetle on Jacob street, Troy, taken 15 June, 1898.

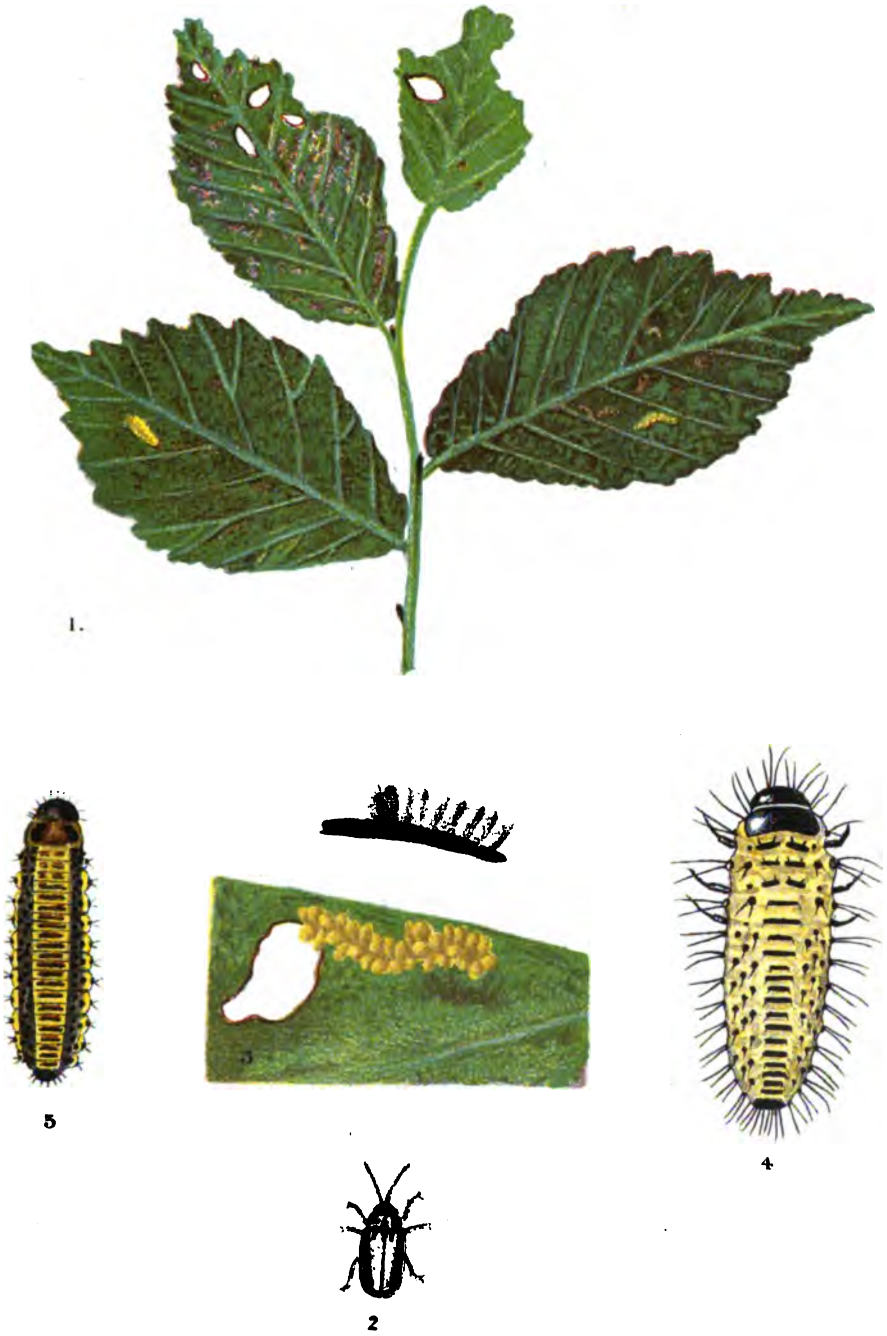
Plate 4

Power spraying outfit at work in Albany, taken 15 June, 1898.

Plate 5

Hand spraying outfit at work in Albany, taken 15 June, 1898.

Plate 1.



Elm-Leaf Beetle.

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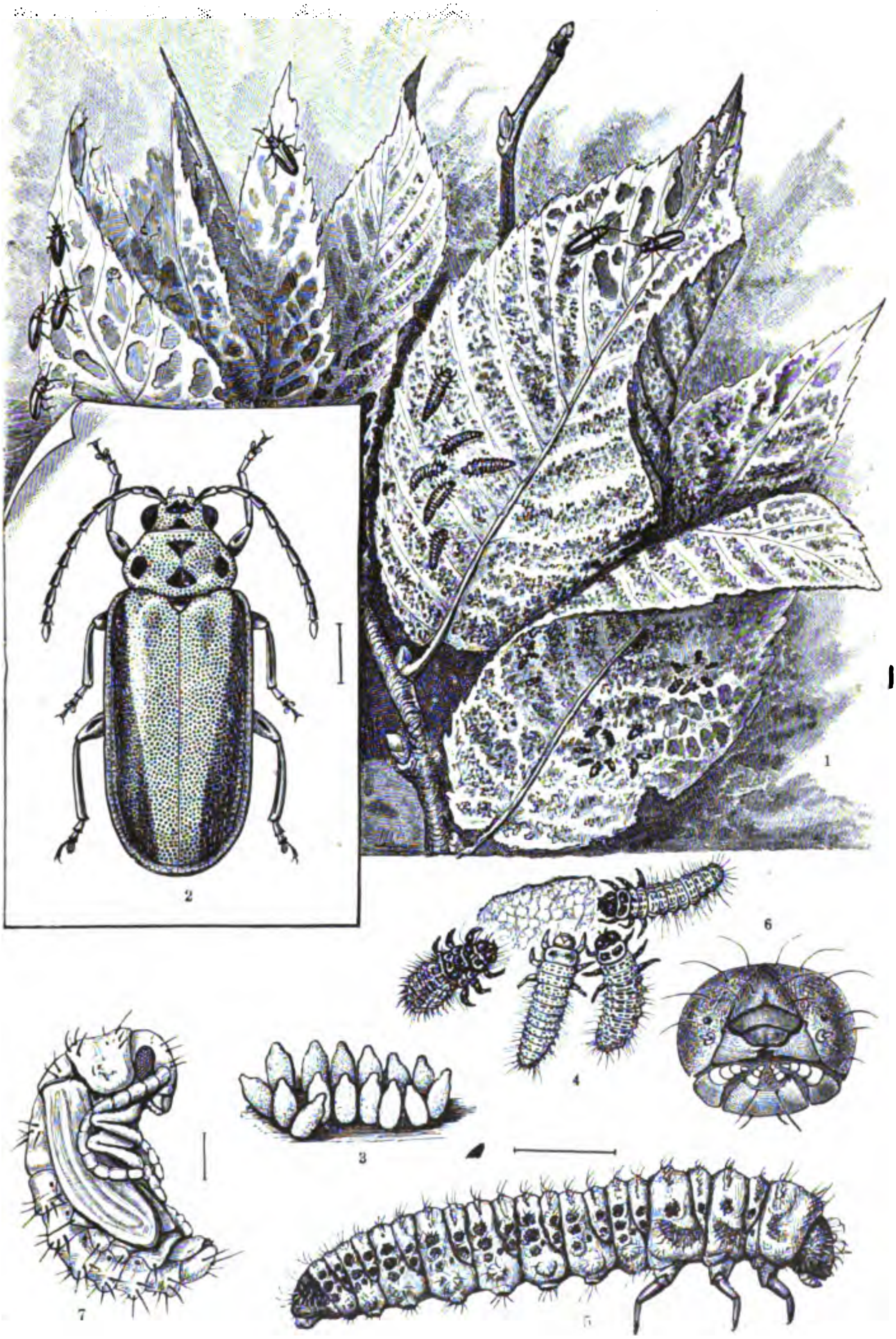
H. M. F. and E. P. F. dels.

W. H. C. Co. State Printers.
Albany New York.

Plate 1a



ELM-LEAF BEETLE
(After Howard [Division Entomology], U. S. Department Agriculture, Year book, 1895)

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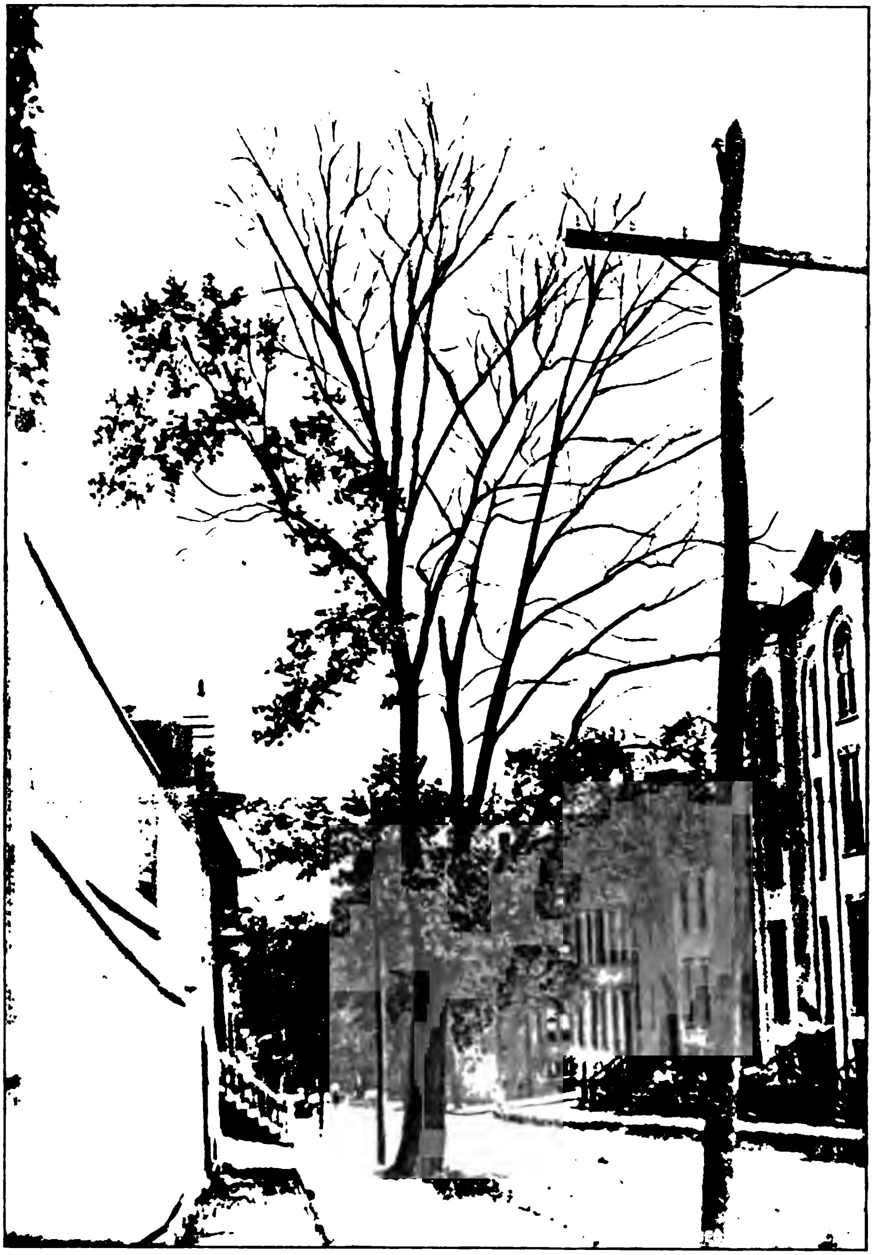
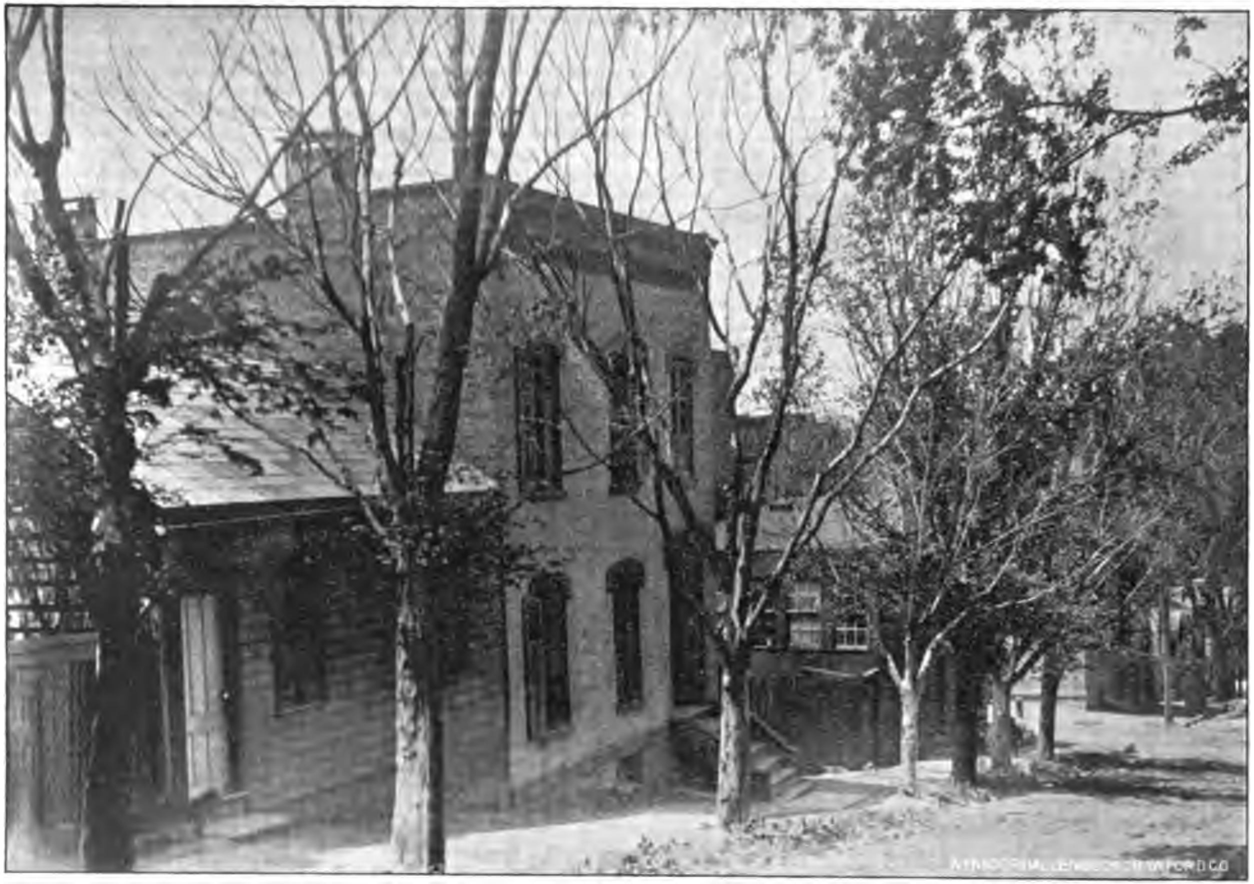


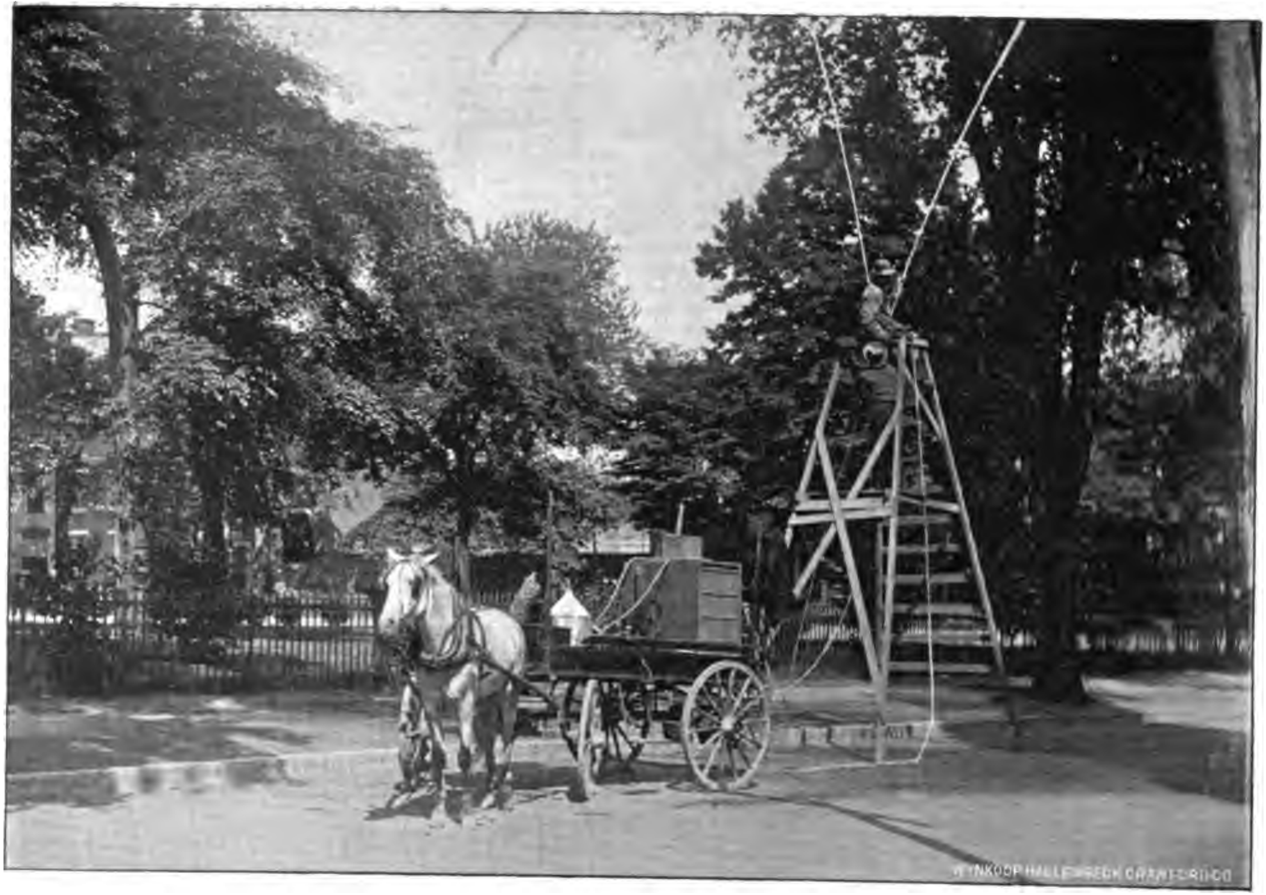
Work of elm-leaf beetle on Elm street, Albany.

Plate 3



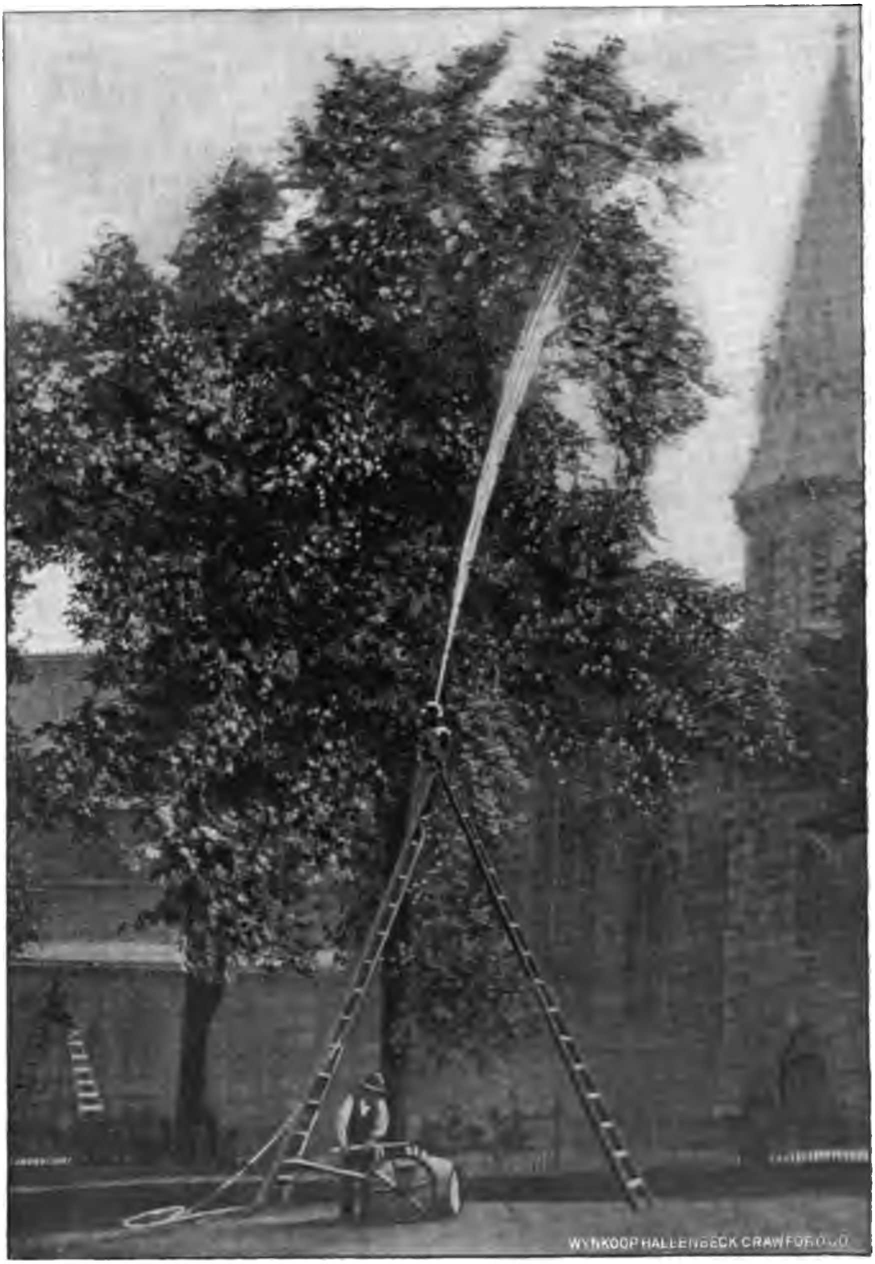
Work of elm-leaf beetle on Jacob street, Troy

Plate 4



Power spraying outfit in operation

Plate 5



Hand spraying outfit in operation

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